RDT

Brief

Research Investigation RI98-007 | July, 2000

Slope Stabilization with Recycled Plastic Pins – Constructability

Description:

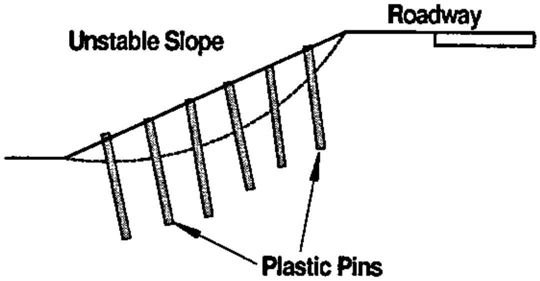

Figure 1. Profile view of RPP stabilization scheme

A new technology for stabilizing earth slopes and embankments was developed for the Missouri Department of Transportation by investigators from the Department of Civil & Environmental Engineering at the University of Missouri-Columbia. The technology uses recycled plastic pins (RPPs), manufactured by pressure-molding recycled polyethylene with a compliment of sawdust and other by-products, to intercept the sliding surface and provide additional resistance to maintain the stability of the slope (Figure 1). The feasibility of the technique was demonstrated through an extensive field and laboratory investigation to evaluate the potential for using RPPs for stabilization of surficial slope failures.

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Procedure:

The primary objective of the project was to demonstrate the constructability of stabilization schemes using recycled plastic pins. RPPs were used to stabilize two slides in an earthen embankment located on Interstate 70 at milepost 62 near Emma, Missouri (Figure 2). The embankment had a history of repeated slope failures, each of which were repaired by pushing the soil back into place. The embankment is approximately 25 feet in height and has slopes of approximately 2H:1V. The soils were a mixture of lean and fat clays with some silt.

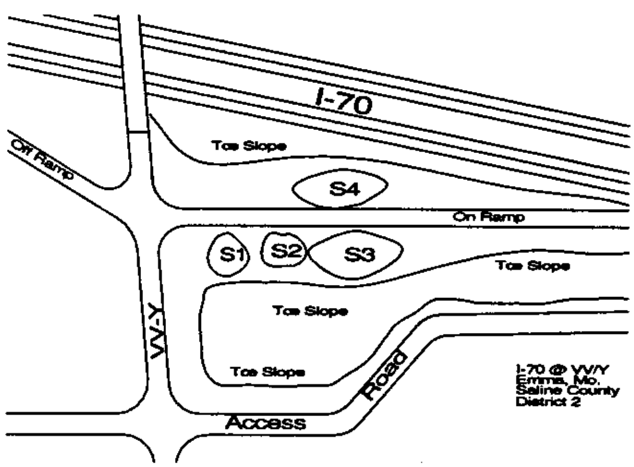

Figure 2. Plan view of Emma site. Slides S1 and S2 were stabilized with RPPs. Slides S3 and S4 were used as control sections.

Results of site investigation and testing were used in combination with a preliminary design methodology to select the field installation plan of using 8-ft. long pins placed on a 3-ft. staggered grid with every other row offset by 1.5-ft. A total of 317 RPPs were installed in the two slides during November 1999. Design analyses indicate that the installed pins will increase the stability (factor of safety) of the slope by about 20 to 25 percent.

Installation of the pins was performed using a Davey-Kent DK 100B crawler mounted drilling rig equipped with a mast capable of forward, backward, and side-to-side tilt (Figure 3).

The drilling mast ensured that the hammer and pin remained aligned during driving to prevent breaking the pins. The crawler-mounted rig easily maneuvered on the slope thereby keeping set up time between pins to a minimum. The rig was equipped with a hydraulic hammer drill attached to the mast providing a maximum of 295 ft-lbs of energy at a maximum frequency of 1800 blows/min. The hammer energy was further augmented by a push/pull of up to 18,000-lbs supplied by the drill mast.

The site was instrumented to enable improvements to design and construction methods. A total of ten pins were instrumented with resistance type strain gages to monitor strains, stresses, and bending moments in the pins in the stabilized and control slopes. Inclinometers and piezometers were also installed in the slide areas to monitor lateral movements and determine groundwater conditions.

In addition to the field demonstration activities, an extensive laboratory testing program was performed to evaluate the mechanical properties, durability, and long-term performance of the recycled plastic materials. The laboratory testing program included simple tension and compression tests as well as bending and shear tests. Tests were performed on virgin specimens as well as on specimens that were exposed to an array of environmental conditions. Sustained loading (creep) tests were also performed.

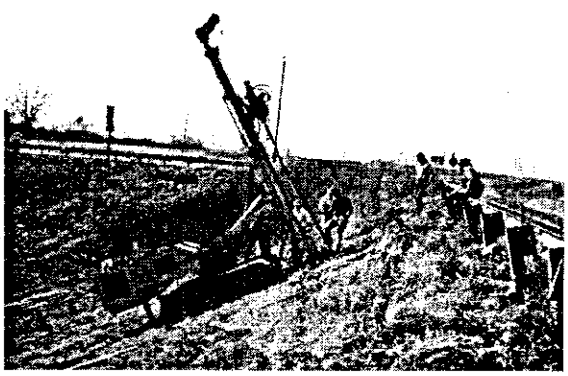

Figure 3. Equipment used for installation of RPPs at Emma demonstration site.

Results:

Field installation activities showed the plastic pins to be remarkably durable with respect to driving stresses, even under hard driving conditions. Installation rates averaged 80 lineal feet per hour. The rate generally increased as personnel gained experience with the operation suggesting that future installation rates may exceed those observed at the Emma site. A mast-guided driving system is recommended to maintain peak installation rates and minimize damage to the pins.

Parametric analyses performed using the preliminary design methodology showed that critical parameters include the depth of sliding, pin capacity, and pin spacing. These analyses also showed that the improvement in stability afforded by plastic pins is similar to that which would be achieved using steel members of the same size and spacing.

All of the slopes at the Emma site have remained stable to date (June 2000). There has been some increase in the loads in the RPPs during recent months due to an increase in precipitation. However, the maximum mobilized bending moments remain less than one-half the capacity of the pins. Precipitation at the Emma site is currently about one inch below normal for the year (2000).

Results from laboratory testing indicate the tensile strength of the recycled plastic ranges from 1.3 to 1.8 ksi and the compressive strength is nominally 3.0 ksi. The plastic material generally maintained these strengths after a year long exposure to acidic water, tap water, freeze-thaw and ultraviolet light. The tensile strength decreased by approximately 50% when exposed to kerosene for one year. Bending creep failure was determined to have low significance after analyses showed effective lifetimes on the order of 1000 years when subjected to current field loads.

The total cost to stabilize the two slides including materials and labor was $11,590. This corresponds to approximately $3.90/ft^2 as compared to estimates of $5.40/ft^2 for rock fill stabilization and $19.00/ft^2 for traditional soil nailing. An expanded field demonstration program is needed to better establish the economics of the RPP stabilization scheme.

Advantages:

The RPP stabilization technology provides MoDOT with an additional alternative for stabilization of shallow landslides. The technology is low cost, makes use of recycled plastics, and provides an easily adaptable design (numbers, size or locations of pins). The pins are highly resistant to chemical and biological attack, are readily available, and can potentially be combined with subsurface drainage features. The completed stabilization provides an aesthetically pleasing vegetative face.

Conclusions:

The field demonstration has shown the RPP stabilization technique to be a feasible and economically competitive alternative to other potential stabilization measures. Three areas that remain to be addressed prior to more widespread implementation of the technique include: determining the range of conditions in which RPPs can be utilized, validating the design technique, and more definitively establishing the economics of the RPP technique as compared to other stabilization alternatives.

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